Narrative Review

Effect of Tattoos on Spinal or Epidural Anesthesia: A Narrative Review

Haixia Yang, MD and Yali Ji, MD

From: Department of Anesthesiology, Qilu Hospital (Qingdao), Cheeloo College of Medicine, Shandong University, Qingdao, China

Address Correspondence:
Yali Ji, MM
Department of Anesthesiology
Qilu Hospital (Qingdao)
Cheeloo College of Medicine
Shandong University
758 Hefei Road
Qingdao, China
E-mail: jiyali880426@163.com

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Background: The popularity of tattoos has increased significantly, particularly among younger demographics. However, the implications of tattoos on medical procedures, such as spinal or epidural anesthesia, are not well established. There is a need to understand the potential risks and complications associated with administering anesthesia through tattooed skin.

Objectives: This narrative review aims to explore the principles of tattooing, the composition of tattoo pigments, the immune response to tattoos, the complications arising from tattoos, and the impact of tattoos on spinal or epidural anesthesia.

Study Design: A comprehensive literature review was conducted to gather information on the interaction between tattoos and anesthesia. The review included studies that examined the effects of tattoos on anesthesia outcomes and patient safety.

Setting: The review spans both clinical and research environments, focusing on the interactions of tattooed skin and anesthesia administration, particularly in regions where tattoos are prevalent.

Methods: Relevant databases were searched for studies discussing the relationship between tattoos and anesthesia. The analysis included examination of tattoo pigments, immune responses, and the potential for complications during the administration of anesthesia through tattooed skin.

Results: The review found that tattoos could lead to various complications, including infections, allergic reactions, and skin lesions. The presence of tattoos does not preclude the use of spinal or epidural anesthesia but may necessitate modifications in anesthetic technique. The pigments used in tattoos, especially organic compounds, can potentially cause neurotoxic reactions if introduced into the spinal canal. Additionally, tattoos may interfere with the body's immune response, leading to localized inflammation and potential nerve injury.

Limitations: The review is limited by the scarcity of studies specifically addressing the interactions between tattoos and anesthesia. The variability in tattoo pigments and individual patient responses further complicates the establishment of standardized guidelines.

Conclusions: While tattoos present potential risks when considering spinal or epidural anesthesia, they do not absolutely contraindicate these procedures. Anesthesia providers should be aware of the possible complications and adapt their practices accordingly. These adjustments may include selecting alternative puncture sites, using caution with MRI and high-frequency electrosurgery, and obtaining detailed information about the tattoo's pigment composition. Further research is needed to establish clear guidelines and to better understand the long-term implications of tattoos on anesthesia safety and efficacy.

Key words: Tattoo, intraspinal anesthesia, complication, anesthesia method

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The art of body tattoos has a long history. In recent years, tattooing has become increasingly common in China, especially among young patients in clinical work, but there is still a lack of relevant data about how tattoos interact with medical procedures. Reportedly, since 2004, the tattooing rate of people under 40 in the United States has been as high as 36%, with young women (including pregnant

women) showing an increasing trend of tattooing on nontraditional sites such as the back, sacrum, and abdomen (1). However, some risks may be associated with anesthesia puncture in the spinal canal at the tattooed site, which has been reported to lead to epidermoid tumors or arachnoiditis (2). Therefore, when treating tattooed patients, anesthesiologists are faced with the challenges of choosing an appropriate anesthesia method and deciding whether to administer intraspinal anesthesia through a puncture in the body. This review focuses specifically on tattoos located at or near the site of the intended anesthesia administration. However, it is important to consider that tattoos on any part of the body may pose risks during certain medical procedures, particularly if pigments or other substances have systemic effects or if the tattoos are associated with widespread skin reactions. In this paper, we review the principle and pigment composition of tattoos, the complications of tattoos, the potential risks of tattoos on spinal or epidural anesthesia, and the choice of anesthesia methods, which may serve as a reference for clinical practice.

Tattoo Principle, Pigment Composition, and Body Immunity

Tattoo Principle and Pigment Composition

In the act of tattooing, a tattoo pigment is injected into the dermis through the epidermis and then deposited along the entire needle track. When the needle penetrates the dermis, some dermal cells are destroyed, the pigment is mixed around the damaged cells, and the pigment remains in a steady state among the cells. The self-repair mechanism of the human immune system will later initiate itself, causing tiny pigment particles to be engulfed by skin macrophages and transported to local lymphatic vessels and perivascular lymph nodes, where they will be finally transformed into a stable fibroblast with the pigment color, rooted between the epidermis and dermis. Only the pigment in the dermis layer will be permanent, and natural skin peeling will not affect the integrity of the tattoo.

Tattoos are classified as either temporary or permanent, and different types of tattoos contain different colors. Temporary tattoos mostly use henna or impatiens. Henna is now often diluted or replaced with p-phenylenediamine (PPD). There is considerable evidence that topical skin reactions to temporary tattoos, such as anaphylaxis, pseudolymphoma, granuloma, and bryoid lesions, are associated with reactions to PPD and other substituted aromatic amino compounds (3). Permanent tattoos are developed using synthetic materials. The material that composes a tattoo's color is divided into 2 parts: color base and auxiliaries. Color base refers to the role of color pigments, dyes, and other organic or inorganic substances. Auxiliaries refer to the materials used in addition to the color base, such as water, alcohol, glycerine, and resin, which play a role in dispersion, wetting, disinfection, emulsification, and other processes. Current materials used in tattoo colors include organic compounds, inorganic compounds, metals, and solvents (4). Changes in chemical composition result in different colors (Table 1).

Laser treatment is currently the gold standard for removing unwanted tattoos. Studies have shown that when laser surgery is combined with the instantaneous killing of skin macrophages in the tattooed area, fragments of pigment particles produced by the laser pulses cannot be captured immediately, increasing the likelihood that they will be expelled through lymphatic vessels (5). Additionally, the combination of laser therapy with cell-specific entosis inhibitors can also facilitate the excretion of released and broken tattoo pigment particles by preventing macrophages or fibroblasts from recapturing them (6).

Tattoos and Immunity

When the tattoo color is injected into the dermis, macrophages can be activated to induce the dermis macrophages to phagocytose exogenous foreign bodies such as metal particles, dead cells, or any other type of particles to prevent the diffusion of potentially harmful substances (7). Moreover, pigment-laden skin has a special type of macrophage called a melanophage, which contains melanin. Originally reported to exist only in human skin (8), melanophages have recently been found in the skin of mice (5). A recent study showed that macrophages in the dermis of tattoo tissue store pigment particles responsible for maintaining the integrity of the tattoo in the dermis (9).

In addition to immune cells, the dermis contains many nonimmune cells, such as fibroblasts, which play an important role in skin homeostasis by producing and degrading extracellular matrix proteins. Furthermore, fibroblasts are involved in wound healing and scar formation. More importantly, studies have shown that fibroblasts are involved in the storage of pigment particles in tattoos (9,10). In a previous study, electron microscopic analysis revealed that pigment particles on the tattooed skin of humans combine with the cell

membranes of fibroblasts to maintain the stability of tattoos (11).

Tattoo Complications

Tattoos can cause a variety of complications, including infections, allergic reactions, tumors, and skin lesions (12). Therefore, for these patients, special attention should be paid to distinguish the complications related to the tattoo itself (especially if it is fresh) from those caused by clinically related operations and treatment. The age of a tattoo can significantly influence the risk of complications during medical procedures, including spinal or epidural anesthesia. Fresh tattoos (typically within the first 3-4 weeks) are more susceptible to infections due to the skin's healing process and the open wounds associated with the tattooing procedure (13). During this period, the risk of bacterial infections, allergic reactions, and other complications is higher. As tattoos age, the skin barrier re-establishes itself, reducing the likelihood of complications, though risks related to pigment composition and potential inflammatory reactions remain. For these reasons, the timing of anesthesia or other invasive procedures should consider the age of the tattoo to mitigate potential risks.

Infection

Tattoos disrupt the skin's barrier function, allowing potential pathogens to enter the body. It is estimated that 1%-5% of tattoo recipients develop tattoo-related skin infections, often from Staphylococcus aureus or Streptococcus pyogenes. The clinical manifestations of these infections vary, with local manifestations including folliculitis, impetigo, cysts, furunculosis, erysipelas, or cellulitis and systemic manifestations including toxic shock syndrome, spinal epidural abscess, endocarditis, and septicaemia (14-18). Signs and symptoms usually appear 4-22 days after the individual receives the tattoo (19).

Fungal infection is rare, but a case of postmortem aspergillus fumigatus infection has been reported (20). For patients who have recently received tattoos, invasive anesthesia operations in the tattooed area should therefore be avoided to prevent infection-related complications. Tattoos can also lead to the potential spread of hepatitis B, hepatitis C, and human immunodeficiency virus (21).

Allergic Reactions

Tattoo allergy is the most common skin complication among tattoo recipients (22-25). There is no universal definition of "allergic reaction" to tattoo coloring. The current accepted view defines it as a chronic and persistent skin reaction that occurs immediately after receiving the tattoo or many years later, regardless of the type or color of the tattoo, and it is usually accompanied by itching. Red is the color most commonly associated with allergic reactions to tattoo pigments. (25). Common symptoms include swelling, papules, nodules, complete infiltration, and sclerosis. Necrosis and ulceration are rare. Skin biopsies are recommended for the diagnoses of allergic reactions caused by tattoos. Various histopathological reactions after biopsies include eczema reactions, lymphohistiocytic reactions, bryophytic reactions, granulomatous foreign body or nodular reactions, and pseudolymphoma (26).

Table 1. *Elemental composition of tattoo pigments.*

Aluminium	Magnesium
Cadmium (yellow)	Mercury (red)
Carbon (black)	Nickel
Chlorine	Nitrogen
Chromium (green)	Oxygen
Cobalt (blue)	Silicon
Copper	Sulfur
Iron	Titanium

Tattoo-Related Tumors

Chronic trauma, scarring, and/or chronic inflammation of the skin can lead to skin cancer, and tattoos can be considered a long-term "scarring process." Tattooing has been reported to cause skin malignancies, including melanoma, basal cell carcinoma, and squamous cell carcinoma (27,28), but the exact mechanism of these complications remains unclear. In recent years, the incidence of tattoo-related keratoacanthoma and pseudoepitheliomatous hyperplasia have also been increasing (29). These lesions are mostly confined to the tattooed areas and are reported to be seen most often in red tattooed areas (27,30).

Skin Burns

Skin burns are also common complications of tattoos. The pigments used in tattoos, especially black inorganic dyes, often contain high concentrations of iron oxide. There have been reports of skin burns and a painful burning sensation at the tattoo site during magnetic resonance imaging (MRI) scans (31). The main issue is that iron oxide can potentially be magnetic and conductive, and the heat produced by MRI scan-

ners can cause skin cells to heat up, leading to burns. Therefore, patients with tattoos, especially those with black tattoos, should be cautious about receiving MRI examinations (32). Additionally, because tattoos often contain metals, the use of high-frequency electrocution during surgery can cause them to form an electric current or act as heat conductors, causing skin burns. Therefore, patients with potentially metallic tattoos (to reiterate, especially if those tattoos are black) should be fully evaluated and explained during pre-anesthesia evaluation, and the specific composition of the colors used in their tattoos should be determined if necessary.

Nerve Injury

Tattoos can also cause nerve injury. Steiner et al (33) reported that 3 patients developed brachial plexus neuropathy with muscle atrophy near the tattoo areas within 3-6 months after receiving their tattoos, which might have been due to an immune response induced by the tattoo pigments or local chronic neuromuscular dysfunctions caused by the pigments' toxic effects. Through animal model experiments, Ferraz et al (34) showed that rabbits could produce clinical signs of meningeal injury when normal saline was injected into the needle sheath through a skin puncture at the tattoo site.

Potential Risks of Administering Intraspinal Anesthesia Through the Tattoo Site

During spinal anesthesia puncture, epidermal tissue may be carried into the spinal canal, resulting in an iatrogenic epidermoid tumor. Choremis et al (35) reported iatrogenic epidermoid tumors in the epidural and subarachnoid spaces of 5 children after multiple intraspinal antibiotic injections. The authors hypothesized that during lumbar puncture, when the hollow needle passed through the skin, tissue with epidermal components was left in the puncture hole and then injected into the epidural or subarachnoid space, resulting in the development of an epidermoid tumor. McDonald et al (36) reported a case of a woman who received multiple intraspinal anesthesia and developed an epidermoid tumor after receiving the fourth round of intraspinal anesthesia during delivery. It is generally advised to avoid invasive procedures, such as injections or spinal anesthesia, in the tattooed area for at least 4-6 weeks after the patient has gotten a tattoo (37). This period allows the skin to heal properly and reduces the risk of complications such as infections or the inadvertent introduction of tattoo pigments into deeper tissues during the procedure. For patients requiring urgent procedures within this time frame, alternative sites or methods should be considered to minimize risks.

Intraspinal anesthesia through skin puncture in the tattooed area may carry pigmented epidermal tissue into the spinal canal and cause neurotoxic reactions. A prospective study conducted by Campbell et al (38) showed that a puncture in the body area may cause the epidermal cells inside the hollow needle to migrate to deeper tissues, leading to potential complications. This problem can occur even with the use of a size-25 Quincke or Whitacre needle. This issue shows that when a hollow needle is used, with or without the needle core, components of a tattoo may enter the puncture needle accidentally. The pigment tissue or negative pressure test may be carried through the epidural space, leading to tissue fragments in the deeper part of the pinhole and subarachnoid epidural clearance and even a nerve toxicity reaction (34,39). In addition, some studies have reported that certain elements used in tattoo colors, such as aromatic amide, have a potential carcinogenic effect. Therefore, , such patients must be informed of the carcinogenic risk before receiving spinal anesthesia (40).

Selection and Consideration of the Anesthesia Method

Because of the potential risks of administering intraspinal anesthesia through a tattooed area, it is difficult to choose an anesthesia method for tattooed patients. General anesthesia has a great impact on hemodynamics and is very expensive. Some patients may refuse general anesthesia due to serious complications and costs. Local anesthesia cannot provide perfect analgesia and is thus not suitable for most surgical requirements, leaving patients with a bad experience and reducing their satisfaction. However, there are no clear guidelines on the selection of anesthesia methods for patients with tattoos in the puncture areas. According to the existing literature, the main methods adopted for the use of spinal anesthesia on such patients include the following: choosing an intervertebral space that does not have a tattoo or is far from the tattooed area, using different access angles, and, if avoiding the tattooed area is impossible, trying to find an area in the tattoo with no pigment. Furthermore, some studies have reported that the skin can be cut before the insertion of the needle, or that the tattooed area can be punctured before the surgery to effectively avoid puncture complications (41).

For patients with lower-back tattoos, the selection of puncture points for anesthesia in the spinal canal should be individualized, and different puncture points and puncture paths should be selected according to the tattoos' positions. If the whole tattoo is located above the conventional puncture site, the conventional puncture site can be selected (Fig. 1A). If the tattoo covers the whole waist and back, the physician can identify a blank area at the conventional puncture point in the tattoo pattern and perform the puncture in that area (Fig. 1B). If the tattoo covers the entire back area and there is no space at the conventional puncture point in the tattoo pattern, a different type of anesthesia, such as general anesthesia, may be considered (Fig. 1C). If intraspinal anesthesia is still required, patients should be clearly informed of the risks of intraspinal anesthesia before the procedure, and the puncture should be performed at sites with fewer tattoo patterns and lighter colors (Fig. 1D).

In addition, for patients who have received tattoos recently, puncture in areas that are tattooed or infected should be avoided as much as possible during the operation to prevent infection-related complications. Since the intraoperative use of high-frequency electrotomes on patients with black tattoos may cause skin burns, preoperative risks should be fully assessed and explained, and the use of high-frequency electrotomes should be avoided as much as possible.

Fig. 1. *Anesthesia puncture sites in 4 patients with tattoos on their backs. (A) A 32-year-old man undergoing mixed haemorrhoidectomy under combined spinal epidural anesthesia. (B) A 37-year-old man undergoing incision and drainage of perianal abscess under combined spinal epidural anesthesia. (C) A 31-year-old man undergoing mixed hemorrhoidectomy under general anesthesia. (D) A 33-year-old male undergoing mixed hemorrhoidectomy under combined spinal epidural anesthesia. The black arrows in the figures indicate the anesthesia puncture point.*

Conclusions

Puncture at the tattoo site may transfer pigmented tissue fragments to deeper sites within the body and cause serious complications such as arachnoiditis or neuropathy secondary to inflammatory responses, but large clinical studies are needed to confirm this possibility. Current guidelines do not provide recommendations on the choice of anesthesia modalities and alternatives to intraspinal anesthesia for these patients. Therefore, we should fully understand the potential risks and serious consequences of administering intraspinal anesthesia through tattooed areas. It is recommended that the physician avoid puncturing the tattooed site or select a light-colored site for puncture during intraspinal anesthesia and, if necessary, choose general anesthesia instead.

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